

# The Comprehensive AOCMF Classification System: Condylar Process Fractures - Level 3 Tutorial

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## Abstract

This tutorial outlines the detailed system for fractures of the condylar process at the precision level 3 and is organized in a sequence of sections dealing with the description of the classification system within topographical subdivisions along with rules for fracture coding and a series of case examples with clinical imaging. Basically, the condylar process comprises three fracture levels and is subdivided into the head region, the condylar neck, and the condylar base. Fractures of the condylar head show typical fracture lines either within the lateral pole zone, which may lead to loss of vertical height, or medially to the pole zone, with the latter ones usually not compromising the vertical condyle to fossa relation. In condylar head fractures, the morphology is further described by the presence of minor or major fragmentation, the vertical apposition of fragments at the plane of the head fracture, the displacement of the condylar head with regard to the fossa including a potential distortion of the condylar head congruency resulting in dystopic condyle to fossa relations and the presence or absence of a loss of vertical ramus height. A specific vertical fracture pattern extending from the head to the neck or base subregion is considered. Fractures of the condylar neck and base can be differentiated according to a newly introduced one-third to two-thirds rule with regard to the proportion of the fracture line above and below the level of the sigmoid notch, which is presented in the classification article, and are basically subdivided according to the presence or absence of displacement or dislocation. In both condylar neck and base fractures, the classification is again based on the above mentioned parameters such as fragmentation, displacement of the condylar head with regard to the fossa, including dystopic condyle to fossa relations and loss of vertical ramus height, that is, according to the measurement of the condylar process. In addition, the classification assesses a sideward displacement including the respective displacement sector at the neck or base fracture site as well as the angulation of the superior main fragment and also considers a potential displacement of the caudal fragment with regard to the fossa, which may occur in fractures affecting additional fracture locations in the mandible. The design of this classification is discussed along with a review of existing classification systems. The condylar process for fracture location was defined according to the level 2 system presented in a previous tutorial in this special issue.

## Keywords

- classification condylar process
- condylar base
- condylar neck
- condylar head

Beyond dispute, fractures of the mandibular condylar process are considered to be most frequent among the different fracture locations of the mandible, with incidences reported between 17.5 and 50%.<sup>1</sup> This article presents the level 3 classification system for fractures of the condylar process and is organized in a sequence of sections dealing with the description of the classification system within topographical subregions along with rules for fracture coding, a series of case examples with clinical imaging and a general discussion on the design of this classification. It includes a more elaborate overview that will allow for comparisons to existing classification systems, which have been a subject of rather controversial discussion over the last decades. Especially for a surgically demanding area such as the condylar process, classification systems are indispensable because they offer a structured framework to communicate effectively about clinical cases, and support the treatment decision and specific surgical process (i.e., nonsurgical vs. surgical management, selection of the appropriate approach, type of osteosynthesis method, provision of special equipment). In the present article, the condylar process for fracture location was defined according to the level 2 system presented in a previous tutorial.<sup>2</sup>

Basically, for the clinician, a condylar process fracture is defined as any fracture which is located above the mandibular foramen and runs from within or above the angle of the mandible into the sigmoid notch or the condylar head. Traditionally there has been a subclassification into deep, medium (intermediate), and high condylar process fractures. This subclassification, however, has always been confused by homonymic classifications restricted to the condylar neck region (i.e., collum mandibulae according to its anatomical definition) and the use of homonymic classification terms for completely different fracture levels in the international literature. This wide range of classifications coexisting on an international level makes comparison between treatment outcomes profoundly challenging<sup>3</sup> and highlights the need

for a validated classification based on reproducible anatomical landmarks.

## Condylar Process Region and Subregion

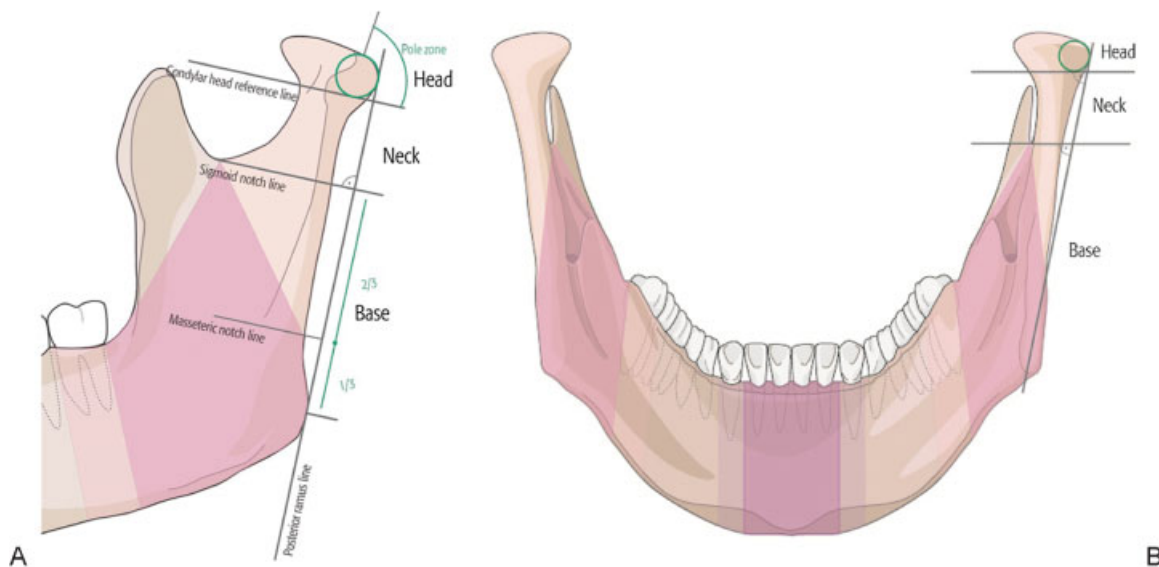
The condylar process stretches upward as a continuation of the posterior border of the ascending ramus and carries the condylar head at the superior end (►Fig. 1) as the lower portion of the temporomandibular joint. The contours of the condylar head resemble to the elliptical shape of a barrel slightly rounded at the lateral and medial poles.

The condylar neck is a clinical term. When viewed posteriorly it corresponds to a trapezoid-like subregion beginning at a level above the mandibular foramen and the lingula. There is no defined anatomic border line between the condylar neck and the condylar head.

The so-called base of the condylar process corresponds to the support zone along the posterior border of the ascending ramus. The point of emergence of the condylar process from the subcondylar base region is not precisely defined anatomically.

For fracture classification, three subregions condylar head, condylar neck, and base of the condylar process are identified according to specific landmarks and reference lines (►Fig. 1). These lines are as follows:

- The posterior ramus line (base line) running along the posterior border of the mandibular ascending ramus, joining the most prominent points of the posterior border of the masseteric tuberosity and the lateral pole of the condylar head.
- The sigmoid notch line (Loukota<sup>4</sup> line) running through the deepest point of the sigmoid notch and perpendicular to the posterior ramus line.
- The condylar head reference line running perpendicular to the posterior ramus line below the lateral pole of the condylar head. The height of the lateral pole is determined



**Figure 1** Lateral (A) and posterior aspect (B) of the condylar process with specific landmarks and reference lines.

by the diameter of a circle (two-dimensional, 2D) or a sphere (three-dimensional, 3D), whose arc best fits with the upper lateral boundaries of the lateral pole. The center of this circle is identified within the bony substance of the lateral condylar head using a caliper with variable radius or a template.

- The masseteric tuberosity notch line running perpendicular to the posterior ramus line at the upper posterior edge of the masseteric tuberosity, which is located at the lower one-third of the distance from the most prominent point of the posterior border of masseteric tuberosity to the sigmoid notch line.

### Level 3 Condylar Process Fracture Classification System

The level 3 focuses on the fracture morphology and bone displacements within the anatomical subregions of the condylar process and is presented in the following sections. While some features relate to the whole condylar process, others are specific to each subregion. A list of diagnostic parameters is presented in ▶Table 1.

#### Condylar Head Fractures

A condylar head fracture is defined when a fracture line involves the area above the condylar head reference line, as assessed on the anteroposterior (AP) view. These fractures are further described based on their location in respect to the lateral condylar pole as condylar head fractures: M = all

fracture lines running medially to the pole zone, or P = at least one fracture line within or lateral to the pole zone (▶Fig. 2).

The morphology of head fracture is described regarding fragmentation, which is defined according to three levels being 1 = nonfragmented, 2 = minor fragmentation, and 3 = major fragmentation (▶Fig. 2). The terms “minor” and “major” refer to fracture patterns that preserve or compromise the integrity of the condylar head, respectively.

Considering fracture displacement, the vertical apposition of the fragments at the fracture plane is assessed as being 0 = complete, with full surface contact at the fracture plane, 1 = partial, with some bony contact at the fracture plane maintained or 2 = lost with no contact over the fracture plane remaining (▶Fig. 3). In doing so, any vertical apposition assessed within or lateral to the pole zone is leading, and in case of several fracture lines, the worst lack of vertical apposition is considered.

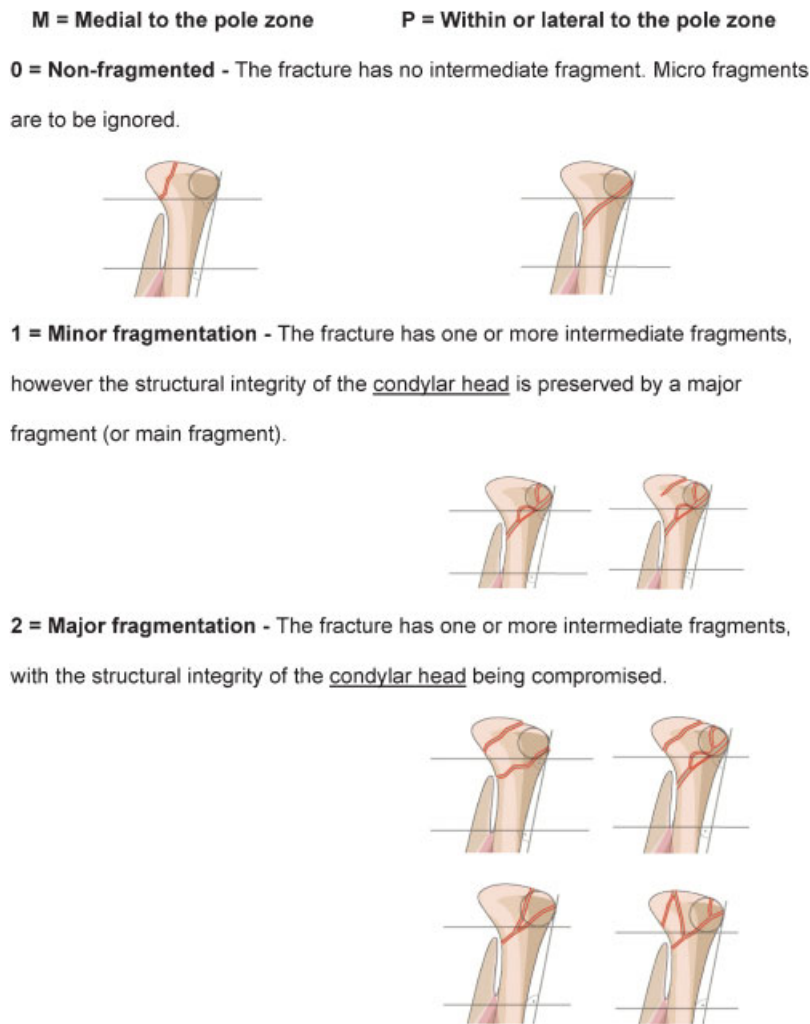
#### Neck and Base Fractures

If a fracture remains caudal to the condylar head reference line (▶Fig. 1), it is located either in the neck or base subregion. A condylar neck fracture is identified when more than a third of the fracture line lies above the sigmoid notch line (assessed on the lateral view) and the line remains below the condylar head reference line (assessed in the AP view). When more than two-thirds of the fracture line runs below the sigmoid notch line in the lateral view, the fracture is involving the base of the condylar process (▶Fig. 4).

**Table 1** Overview of diagnostic parameters in the level-3 condylar process system

Specific level-3 condylar process system		Subregions			
Parameters	Code and description	Process	Head	Neck	Base
Location	M = Medial to the pole zone/P = within or lateral to the pole zone		x		
Fragmentation	0 = None/1 = fragmented minor/ 2 = fragmented major		x	x	x
Vertical apposition	0 = Complete/1 = partial/2 = lost		x		
Sideward displacement	0 = None/1 = partial/2 = full			x	x
	Direction a = anterior/p = posterior and m = medial/l = lateral			x	x
Angulation	0 = None (up to 5 degrees)/1 = > 5–45 degrees/ 2 = > 45degrees			x	x
	Direction a = anterior/p = posterior and m = medial/ l = lateral			x	x
Displacement head fragment/fossa	0 = No displacement/1 = displacement/2 = dislocation	x			
	Direction a = anterior/p = posterior and m = medial/ l = lateral	x			
Displacement caudal fragment/fossa	0 = No displacement/1 = displacement	x <sup>a</sup>			
	Direction a = anterior/p = posterior and l = lateral	x <sup>a</sup>			
Distortion of condylar head	0 = orthotopic/1 = dystopic	x			
Overall loss of ramus height	0 = No change of height/1 = loss of height/ 2 = increase of height	x			

<sup>a</sup>Only in case of neck or base fracture.



**Figure 2** Topography and fragmentation of condylar head fractures. Note: If the fracture is fragmented, the most lateral line should be considered for location as p or m.

Within the neck or base subregions, fractures are classified regarding fragmentation similarly to head fractures, however the terms “minor” and “major” refers to fracture patterns that preserve or compromise the integrity of the condylar process, respectively (► **Fig. 4**).

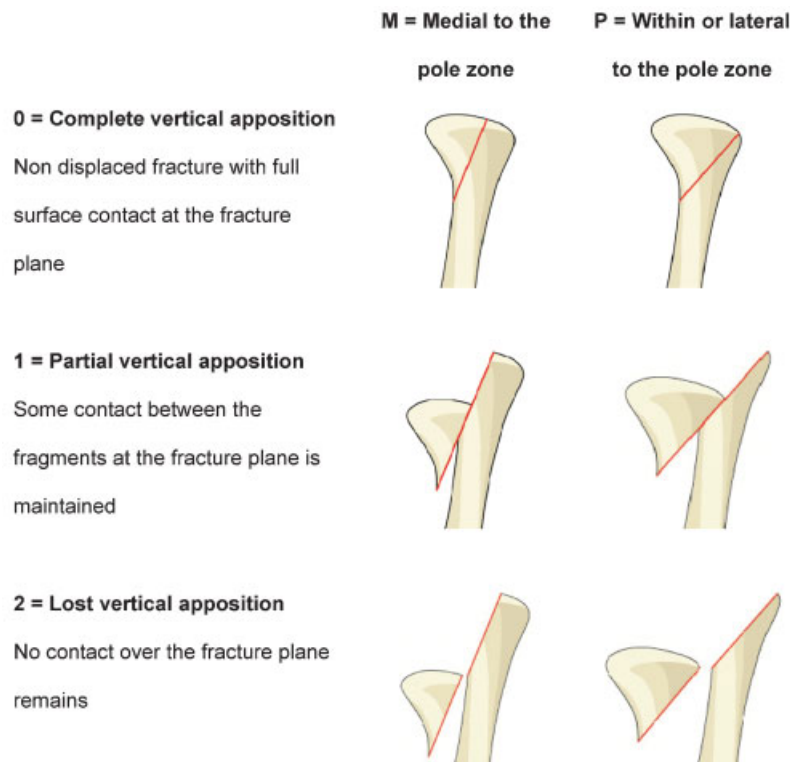
Fracture displacement is documented by sideward displacement at the fracture site and fracture angulation. Sideward displacement is determined in the AP and lateral views according to the remaining contact and position of the fracture plane of the superior main fragment with regard to the fracture plane of the inferior main fragment as 0 = absent (none), 1 = partial or 2 = full (► **Fig. 5**). The direction of displacement is assessed by two parameters related to anterior/posterior and lateral/medial displacement, respectively, considering the major portion of the fracture plane.

The angulation between the midline axis of the displaced superior fragment and the midline axis of the caudal fragment is assessed on the frontal and AP views and categorized in one of the three groups: 0 = no angulation (up to 5 degrees), 1 = angulation up to 45 degrees, or 2 = angulation more than 45 degrees (► **Fig. 6**). The direction of angulation is assessed by two parameters related to anterior/posterior and lateral/medial angulation, respectively.

### Condylar Process Parameters

Any fracture pattern within the condylar process will result in at least two main fragments, one bearing partly or fully the condylar head (hereafter referred to as the condylar head fragment), and the other related to the rest of the mandible (ramus stump hereafter referred to as the caudal fragment). The displacement of both fragments with regard to the fossa, the distortion of condylar articulating surface congruence, and the overall loss of ramus height are documented once for each fractured condylar process, independently to the fracture location and topography (► **Table 1**).

The displacement of the condylar head fragment deals with a permanent nonphysiologic position of the condylar head outside of the glenoid fossa, with the outer limits of the fossa defined by the crest of its rim. On the sagittal plane, the most caudal prominence of the articular eminence is the anterior limit of the fossa. The crest of the rim of the articular fossa is the posterior limit. This displacement is recorded in three categories using frontal, axial, and sagittal views (► **Fig. 7**): 0 = no displacement, when the head remains within the limits of the fossa, 1 = displacement, when part of the head is outside the fossa limits, or 2 = dislocation, when the entire head is displaced out of the fossa limits. The



**Figure 3** Vertical apposition of fragments at the plane of head fracture. Note: In case of several fracture lines, the worst vertical apposition is assessed.

direction of displacement with regard to the center of the fossa is assessed by two parameters related to anterior/posterior and lateral/medial displacement, respectively.

The displacement of the upper end of the caudal fragment (ramus stump) with regard to the fossa is documented for all head and neck fractures in one of the two categories (0 = no displacement/1 = displaced) along with the direction of any displacement by two parameters related to anterior/posterior and only lateral displacement, respectively (►Fig. 8).

In case of no head displacement, the congruence of the articulating surfaces can be distorted due to rotation and/or angulation of the head within the limits of the fossa (►Fig. 9). The occurrence of distortion is assessed in one of two categories; 0 = orthotopic, 1 = dystopic.

The overall change of ramus height is documented in one of three categories: 0 = no change of ramus height, 1 = loss of ramus height, and 2 = increase of ramus height. The ramus height of the fractured side is compared with the contralateral side as measured by the method described by Eckelt et al (►Fig. 10).<sup>5</sup> In case of bilateral fractures, the assessing surgeon should provide his best clinical judgment, in particular when the fracture is associated with signs of override (neck and base fractures) or loss of vertical apposition (head fractures).

### Vertical Fracture Pattern

There exists a special vertical fracture pattern involving several levels of the condylar process, for example, the condylar head and neck, sometimes even including the

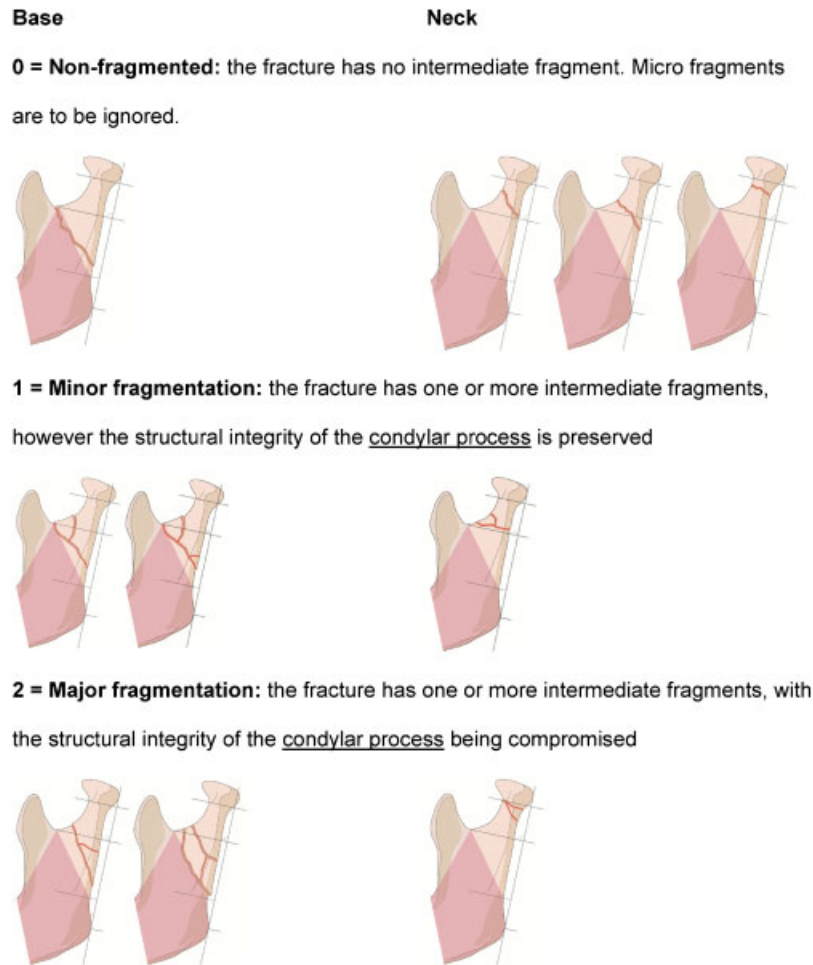
condylar base and ramus. Fractures involving both the condylar head and extending vertically to the condylar neck or base are identified and counted as single fractures instead of separate head, neck, and base fractures.

### Fossa Fracture

The occurrence of a fossa fracture can be documented as whether it involves the temporal bone, the sphenoid bone, or both, within the context of the skull base classification system.<sup>6</sup>

### Fracture Coding

Fractures of the condylar process are identified with the two digit code 91 and the letter P.<sup>2</sup> In coding, these fractures according to their location in the level 3 system, each fractured subregion is identified by a letter (►Fig. 1), which stands for H = head, N = neck, and B = base. A specific condylar process fracture code is defined whereby the letters specifying the involved subregions are added one after the other along with a number for fracture morphology. Displacement parameters are not included in the code; however they remain documented as part of the fracture diagnostic process. For instance, the code "Hm0.B2" illustrates the combination of a nonfragmented head fracture medial to the pole zone with a base fracture with major fragmentation. Yet a fracture with a vertical pattern affecting the head, neck, and possibly base subregions will be coded as one fracture only. To indicate the continuity, the code therefore is specified adding a hyphen "-", so considering the example above the code would read "Hm0-N2."



**Figure 4** Fragmentation of neck and base fractures. Note: The terms "major fragmentation" is often taken as synonym to "comminution" or shattering of the bone into pieces.

## Case Examples

A few case examples are presented to illustrate the classification process. The first case example (►Fig. 11) shows a typical base fracture (right hand side) with lateral override. The fracture height can easily be identified via OPG (orthopantomogram) allowing for the application of the Loukota-line.<sup>4</sup> Alternatively, in case of solely computed tomography (CT)-based diagnostics, the slices with the most caudal position of the small fragment must be assessed preferably in coronal and sagittal views, the latter ones then being mandatory for the definition of the fracture level.

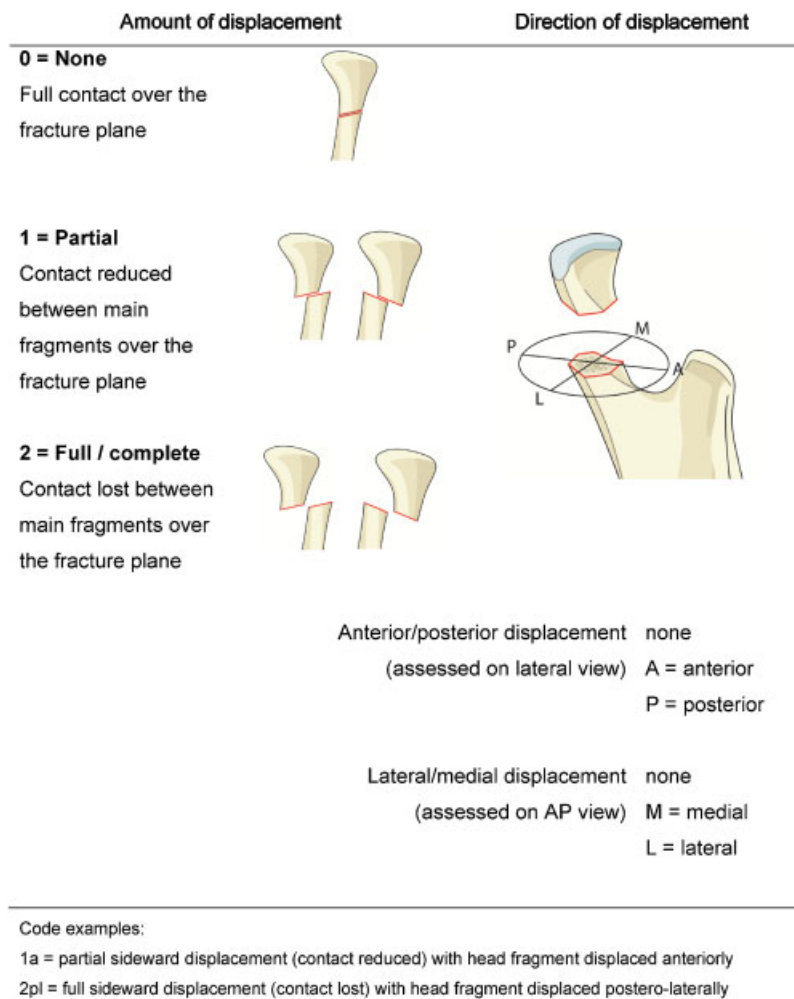
The next case example (►Fig. 12) shows a typical neck fracture (right hand side) in the lower portion of the neck area, once more with lateral displacement of the proximal fragment, the assessment of the fracture level is performed with regard to the sigmoid notch according to Loukota et al.<sup>4</sup> In contrast to Loukota et al, however, the exact fracture level in our classification system is based on a one-third rule, that is, a fracture is classified as a neck fracture when at least a third of the fracture line is located above the Loukota line. Giving more weight to the fracture line within the condylar base subregion, that is, applying the conventional 50/50 rule

(6) would lead to a misclassification in a significant portion of condylar process fractures, which according to clinical judgment should rather be classified as neck fractures.

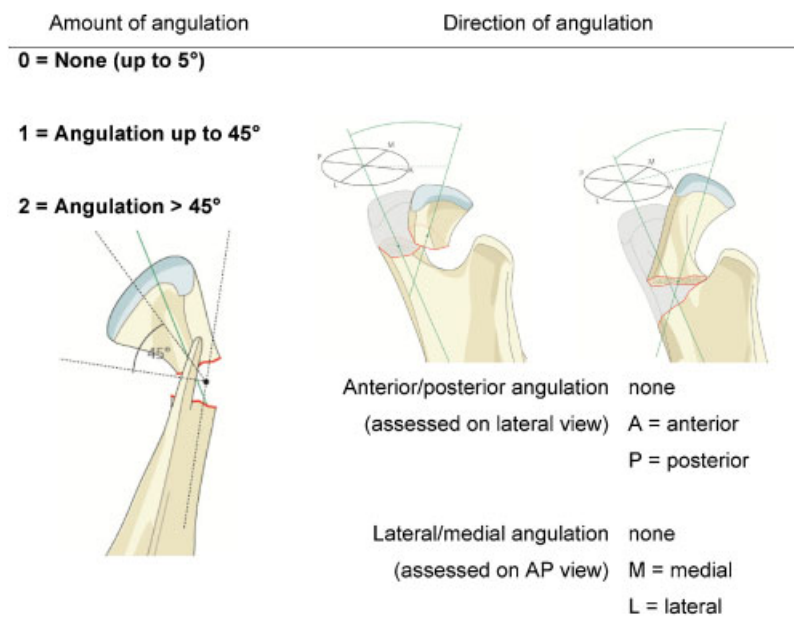
The third case (►Fig. 13) presents a typical bilateral condylar head fracture showing the anteromedial displacement of the proximal fragment, both head fractures are again located within the lateral pole zone area (P). A range of additional fracture patterns are presented in a case collection appendix<sup>7</sup> as electronic supplement of this special issue ([www.aocmf.org/classification](http://www.aocmf.org/classification)).

## Discussion

Beyond dispute, fractures of the mandibular condyle are considered to be most frequent among the different fracture locations of the mandible, with incidences reported between 17.5 and 50%.<sup>1</sup> In contrast to fractures of the cranial vault, skull base, and midfacial fractures, the management of fractures of the mandibular condylar process will usually be performed first of all by oral and maxillofacial surgeons, less frequently by plastic or otolaryngology-head and neck surgeons. Though one might expect these specialists with experience in the field of mandibular traumatology therefore

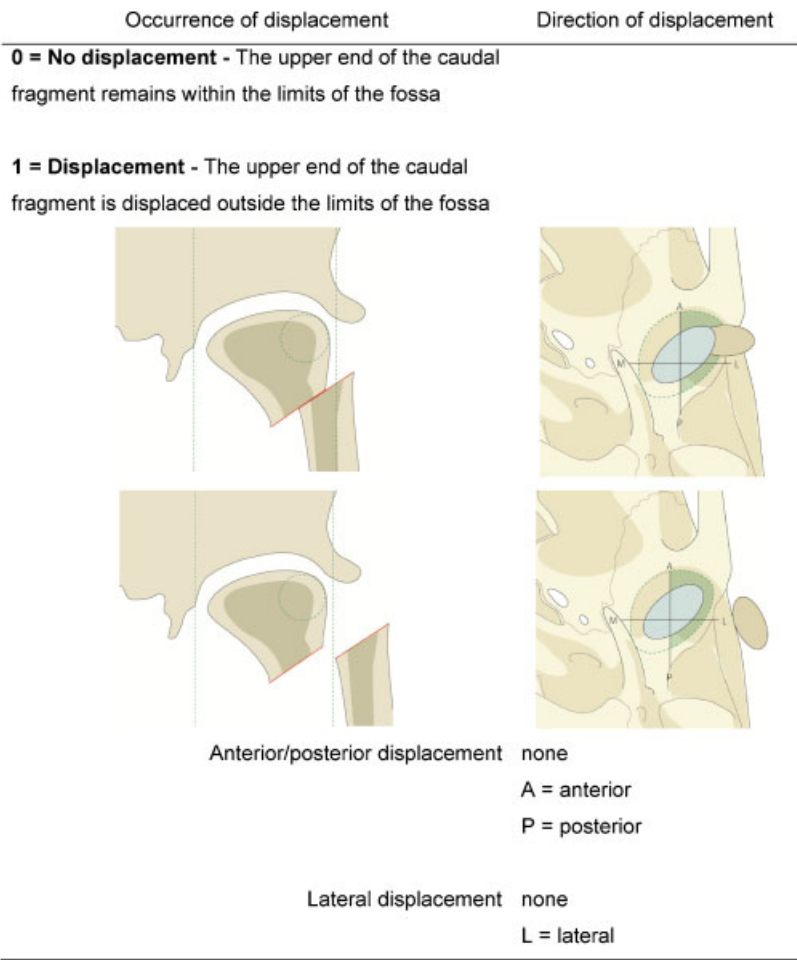


**Figure 5** Sideward displacement at neck or base fracture site.



**Figure 6** Angulation of superior main fragment at neck or base fracture site. Note: The midline axis of the ramus/neck stump is the center line parallel to the best fitting posterior border of the condylar process (after virtual reconstruction of the pretrauma anatomy). The midline axis of the condyle bearing fragment is determined in a frontal and/or anteroposterior plane as the center line passing through the midpoint of the articular surface and the mid-point of the related fracture plane.

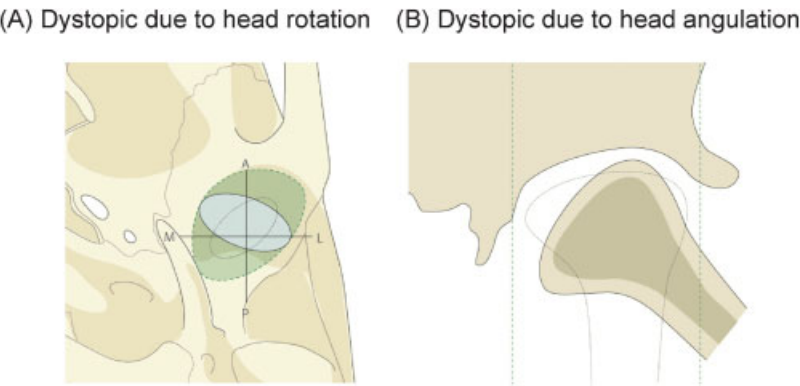




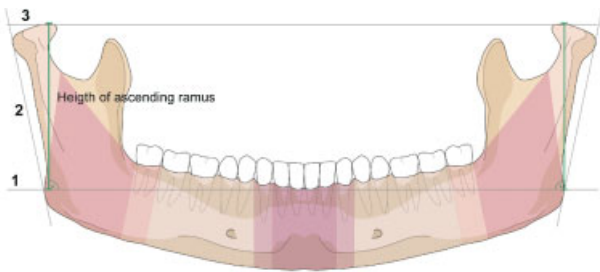
**Figure 8** Displacement of caudal fragment with regard to the fossa. Note: The outer limits of the fossa are defined by the crest of its rim. On the sagittal plane, the most caudal prominence of the articular eminence is the anterior limit of the fossa.

retromandibular, transparotideal, preauricular, and retroauricular as well as the transoral approach,<sup>12</sup> allowing a sufficient localization and exposure of condylar base, neck, and head fractures, which is mandatory for correct anatomical reposition and the application of stable osteosynthesis methods. This grand advancement in condylar process traumatology, however, was also largely due to the advancements in X-ray imaging, with CT enhancement and immediate availability in the emergency rooms allowing a significantly better

preoperative evaluation of the fracture lines and position of the fragments. Currently, an orthopantomogram in combination with a computerized tomogram (obligatory coronal and axial view, preferably supplemented by a sagittal view) are considered as “golden standard” in condylar process fracture diagnostics and allow more difficult diagnoses to be made, especially regarding condylar head fractures, the latter one's going often undiagnosed in the pre-CT era. CT or recently also cone beam CT offer differentiated sectional images, allowing



**Figure 9** Distortion of condylar head articular congruency.

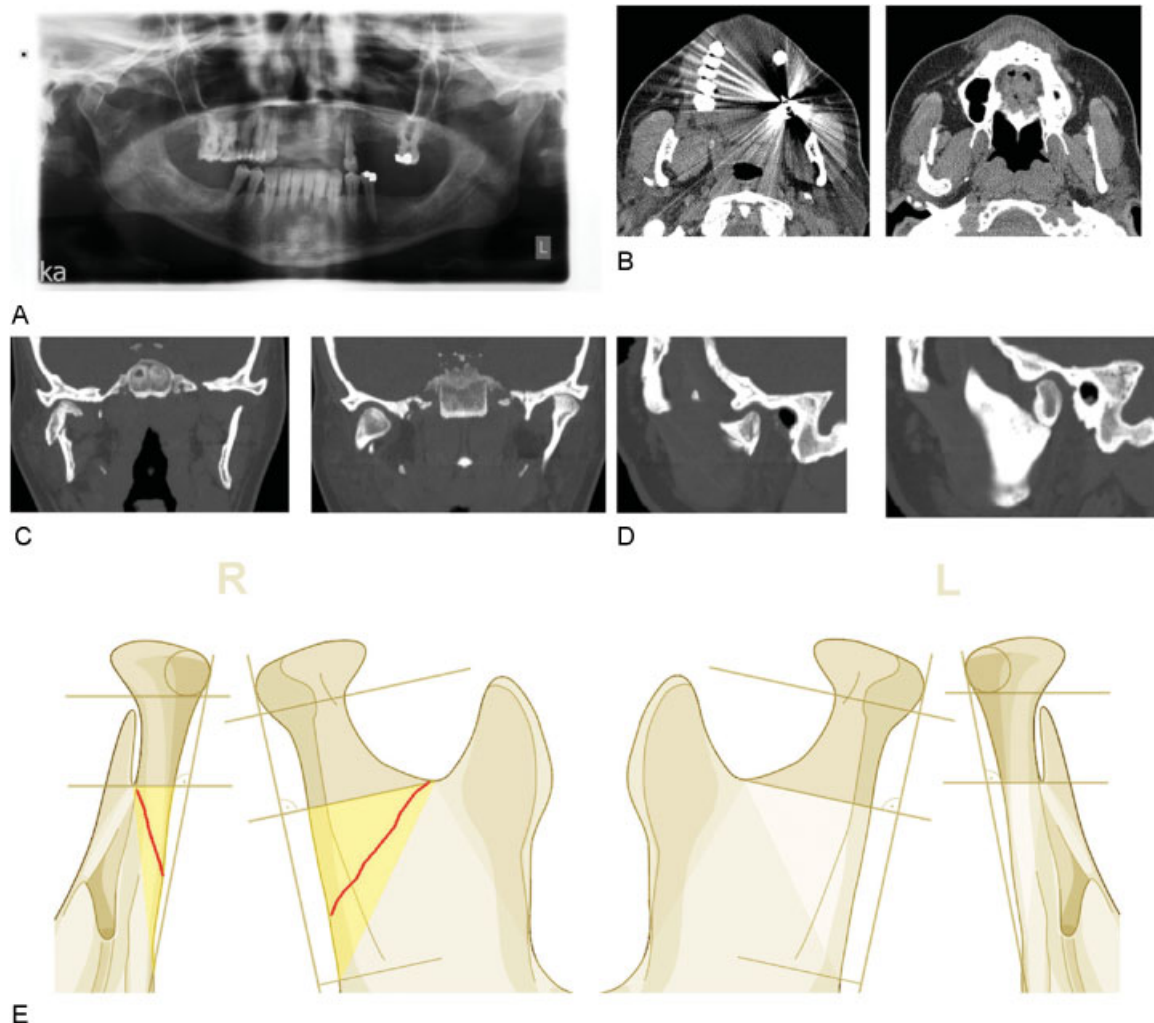


**Figure 10** Measurement of the height of the ascending ramus (according to Eckelt et al<sup>4</sup> 1, horizontal line through the angle of the mandible [most prominent point of the posterior border of masseteric tuberosity]; 2, posterior ramus line and 3, horizontal line through the upper end of the condyles).

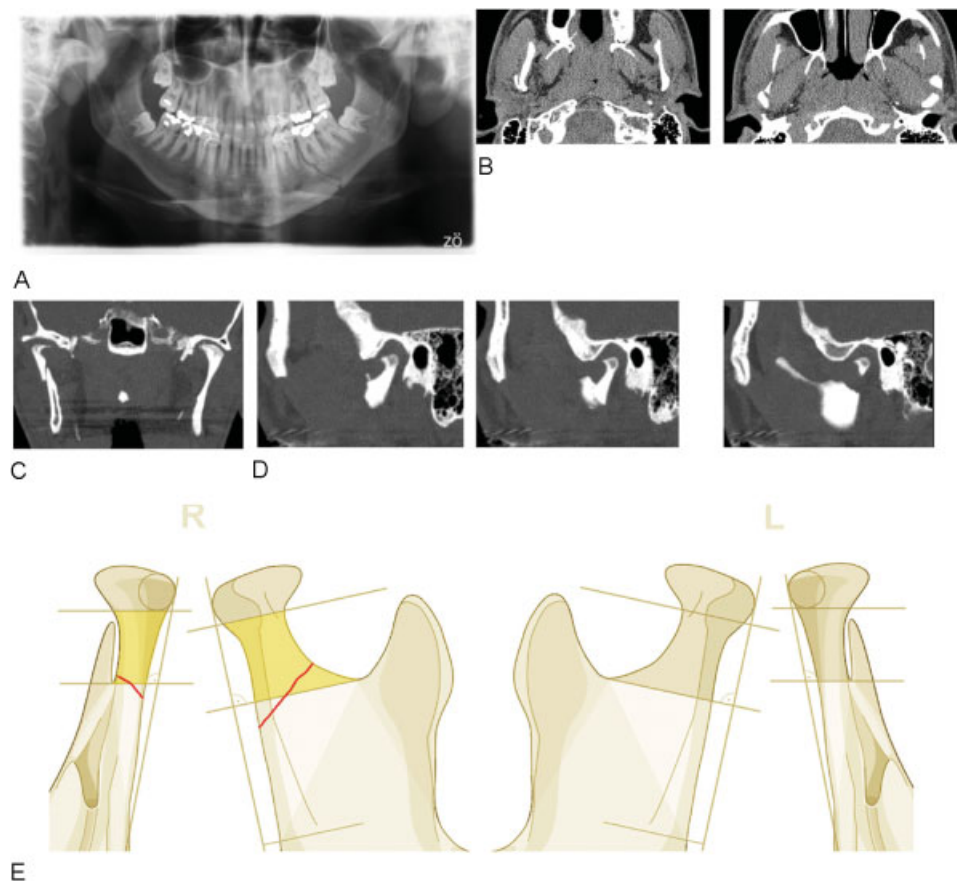
assessing fracture height and rather precise degree of angulation, displacement or dislocation. 3D reconstructions facilitate a proper classification, especially for the upper neck and head region.

Last but not the least, this improvement in preoperative X-ray imaging, in combination with corresponding anatomical knowledge gained by increasing indications for open surgery, also took great influence upon the current classification of condylar process fractures, which in turn is a prerogative for an appropriate handling of the fractures of the mandibular condyle.

The wide range of classifications coexisting on an international level makes comparison between treatment outcomes profoundly challenging.<sup>3</sup> Mc Lennan and Glas<sup>13</sup> proposed a classification differentiating between extra- and intra-articular fractures. The apprehension of the topography and morphology of condylar head fractures, however, has dramatically improved with the advent of CT-imaging techniques. In essence condylar head fractures turned out as shearing fractures with a typical sagittal course in a laterocranial to a mediocaudal direction. The traditional distinction between an intra- and extracapsular location to delineate a condylar head fracture therefore is no more valid, as fractures through the condylar head have been shown to



**Figure 11** Unilateral condylar base fractures with lateral override. Imaging: X-rays OPG (A), CT axial views (B), CT coronal views (C), CT sagittal views (D). Description: Nonfragmented condylar base fracture right hand side, with complete anterolateral sideward displacement, medial angulation up to 45 degrees, no displacement of the condylar head with regard to the fossa, however dystopic. A loss of ramus height is noted. (E) Level 2 Code: 91 P. Level 3: B0. This case example CMTR-91-101 is made available electronically for viewing using the AOCIOAC software at [www.aocmf.org/classification](http://www.aocmf.org/classification).

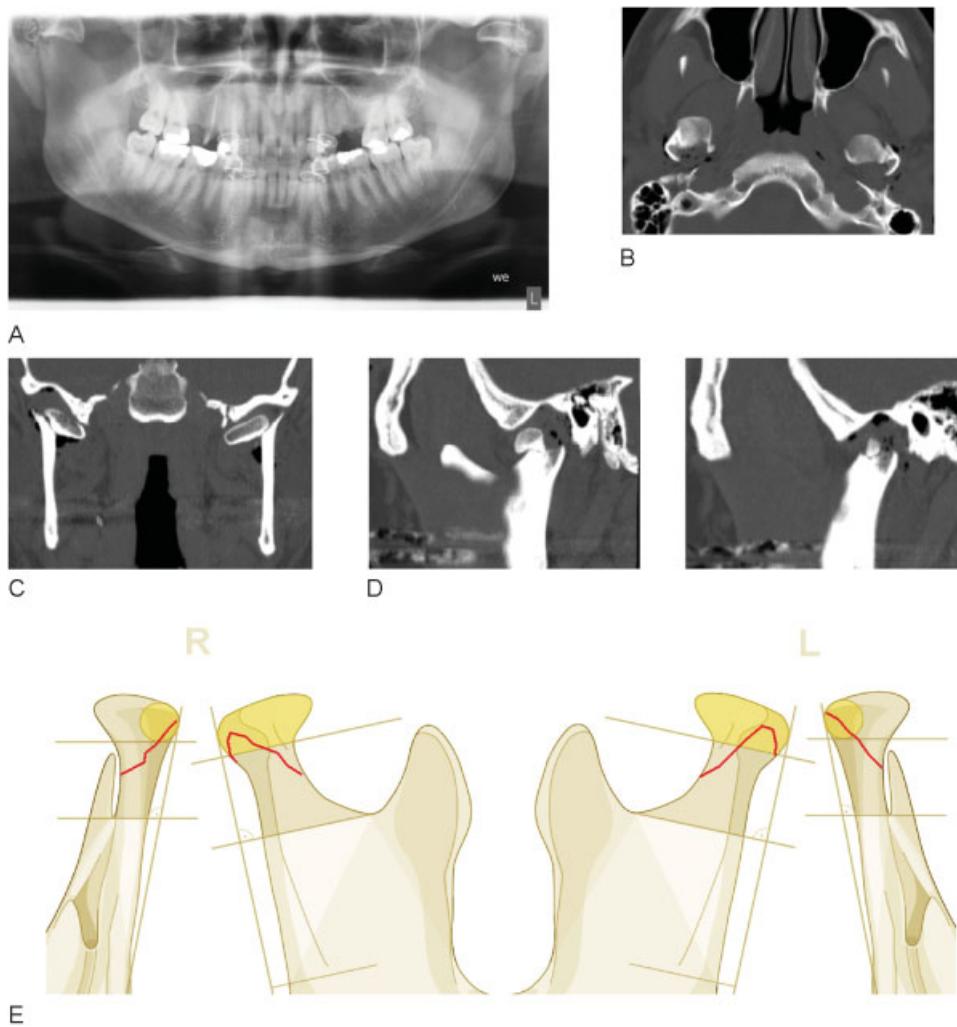


**Figure 12** Condylar neck fracture. Imaging: X-rays OPG (A), CT axial view (B) and sagittal view with small fragment (s) (C), CT sagittal views allowing for a definition of the sigmoid notch (D). Description: Nonfragmented condylar neck fracture on the right hand side, with complete anterolateral displacement, no angulation. The relationship between condylar head and fossa is anatomical, without displacement of the caudal fragment towards the fossa and orthotropic position of the condylar head, a loss of ramus height is noted. There is a concomitant nonfragmented fracture confined within the left mandibular body. (E) Level 2 code: 91 P.m.B. Level 3: N0. This case example CMTR-91-103 is made available electronically for viewing using the AOCMIAC software at [www.aocmf.org/classification](http://www.aocmf.org/classification).

encroach on extracapsular bony portions on the medial or dorsal aspect of the condylar neck. Based on surgical experiences, as already in the early 1990s, Rasse<sup>14</sup> was able to show in a CT-based study, that fractures of the condylar head typically present both intra- and extra-articular fracture lines and therefore coined the term of diacapitular fracture. If the medial fragment in condylar head fractures undergoes a displacement it follows—almost without exception—a stereotypic pathway. According to its vector the lateral pterygoid muscle pulls it out of the glenoid fossa into an anteromedial position. Since the medial fragment leaves the glenoid fossa a displaced condylar head fracture represents a dislocation fracture. Equally, every displacement of the medial condylar head fragment is associated with a displacement out of the fossa. Nevertheless, condylar head fractures are still frequently referred to as intracapsular fractures, most probably due to a lack of knowledge of the corresponding anatomical site. In this context, a further point for repetitive confusion especially in the German speaking countries lies in the homonymic term “dislocation” and the German *Dislokation*, which means “displacement.” Basically, the English classification terms regarding malposition of condylar process fractures are deviation, displacement, and dislocation, with displacement describing just a deviation of the proximal fragment, while the

shifted fragments are still more or less in contact. Displacement (German term *Dislokation*) means loss of contact of the fragments, with a condyle to fossa relation that remains basically intact, whereas dislocation describes the exarticulation of the condyle-bearing fragment out of the fossa (German term *Luxation*). For the clinician, however, this classification regarding malposition is of utmost importance for the decision-making regarding nonsurgical versus surgical therapy of condylar process fractures.

In the past, there have already been multiple attempts to classify the fractures of the mandibular condylar process according to their anatomical position. Köhler distinguished fractures of the head, subcondylar fractures, as well as medium and deep condylar neck fractures at the level of the sigmoid notch.<sup>15</sup> Reichenbach identified high and deep condylar neck fractures.<sup>16</sup> Wassmund related fractures also to the cause of trauma with vertical collum fractures including fractures of the condylar head, transversal, and diagonal condylar neck fractures.<sup>17</sup> It is noteworthy that these elder classifications were primarily based on conventional radiological X-rays<sup>18</sup> and were not calibrated by surgical experiences, especially for the neck and head region. Nevertheless, a basic classification according to anatomical criteria has always been in general use among clinicians. In 1977 Lindahl



**Figure 13** Bilateral condylar head fractures. Imaging: X-rays OPG (A), CT axial view (B), CT coronal views (C), CT sagittal views left and right hand sides, respectively (D). Description: Bilateral nonfragmented condylar head fractures located within the pole zone area with partial vertical apposition. In both fractures there is anteriomedial displacement and the ramus stump is partially displaced laterally, there is a dystopic distortion of the condylar head, and loss of ramus height is registered. (E) Level 2 Code: 91 P.m.P. Level 3: Hp0.m.Hp0. This case example CMTR-91-105 is made available electronically for viewing using the AOCOIAC software at [www.aocmf.org/classification](http://www.aocmf.org/classification).

and Hollender proposed a trendsetting classification, subdividing the condylar process according to the height of the fracture as fractures of the “condylar head,” the “condylar neck,” and the “subcondylar region.”<sup>18</sup> This classification was standardized in 2005 by Loukota et al according to defined anatomical landmarks, subdividing the condylar process now more precisely into fractures of the condylar base, fractures of the condylar neck and diacapitular<sup>4</sup> or fractures of the condylar head, respectively.<sup>19</sup> Nevertheless, the degree of displacement or dislocation, which are decisive from a surgical point of view, are not represented in this widely accepted and reproducible classification. Whereas classifications with regard to the insertion of the lateral pterygoid muscle,<sup>20,21</sup> failed to establish themselves, the classification according to Spiessl and Schroll<sup>22</sup> has made its way into clinical and scientific use, differentiating between low or high condylar fractures without displacement, with displacement or dislocation, respectively, and condylar head fractures. Though the Spiessl and Schroll classification is coming increasingly into use, for example, for comparative studies,<sup>5</sup> it does not allow a

precise assessment of the degrees of angulation, displacement or dislocation and fails to specify defining borderlines between low or high fractures. As precise definitions of high and deep fractures were missing, Loukota et al—with special regard to the Spiessl and Schroll basic discrimination of “low” versus “high” fractures—defined the sigmoid notch as the point of determination between the high (neck) and low (base) condylar process.<sup>4</sup> Furthermore, the above mentioned current classifications do not explicitly demarcate the direction of displacement or dislocation (medially, laterally, ventrally, and dorsally), with medial or lateral displacement of the small fragment being a major factor for the clinical decision-making, for example, regarding extraoral versus transoral approaches to the condylar base and lower neck.

As far as the condylar head region is concerned, Rasse's diacapitular classification<sup>14</sup> was widened out following augmenting surgical experience with fractures of the temporomandibular joint. Considering common surgical procedures and aspects of indication for diacapitular and fractures in proximity to the lateral ligament, Neff et al<sup>23</sup> included the

latter ones into the entity of head fractures. Under prognostic considerations head fractures were further basically subdivided into fractures with or without loss of vertical height.<sup>19,23</sup> Further subclassifications were introduced regarding anatomical fracture locations of the head<sup>23,24</sup> and comminution.<sup>25</sup> Though the treatment of condylar process fractures, and even more so of the condylar head area is still a highly controversial topic, the enormous developments in this field over the last two decades has led to a shift of the focus of interest to the surgical approaches and the discussion of optimized osteosynthesis methods. As long as conservative (i.e., nonsurgical) or functional treatment was applied uniformly to all fractures of the condylar process or at last the whole of condylar neck and head fractures with displacement or dislocation, the specific fracture pattern remained more or less a matter of academic interest or the purpose of documentation. At present, with efficient and stable osteosynthesis methods and even new materials at hand, an up to date classification of the condylar process must meet the following demands, first of all from a clinical point of view, though should also remain based on essential biological characteristics, that is, fracture topography and morphology.<sup>26</sup>

1. Precise anatomical description of the fracture level location with regard to the selection of the best fitting approach and also osteosynthesis method, that is, which will allow best visualization and application of a stable osteosynthesis (e.g., the preauricular or retroauricular approach for high condylar neck and head fractures, the anteroparotideal/transparotideal or conditionally the retromandibular approach for lower neck fractures, the angular, retromandibular or the transoral approach where appropriate for base fractures) but also timing of nonsurgical or functional treatment regimes.
2. Assessment of the direction of displacement of the proximal fragment (first of all medially or laterally) in condylar base and neck fractures with regard to the selection of fractures amenable to osteosynthesis via transoral approaches.
3. Information about the amount of vertical height reduction, the degree of angulation (deviation) or dislocation under prognostic aspects and for the decision-making of closed or open treatment.
4. Provision of specifying information with regard to the selection of adequate nonsurgical or osteosynthesis procedures or the overall functional outcome after closed or open treatment, such as major or minor fragmentation or alterations of the condyle to fossa relation.

One of the early essential experiences during the assessment sessions was the necessity to demand a rather high level regarding the minimum requirements for diagnostic images. The classification group had agreed on CT scans (1–2 mm slices) in standard 2D format in axial, coronal, and sagittal reconstruction. In addition a panorex and open mouth Townes view with both condyles visible were to be provided (alternatively a 3D-CT reconstruction). For assessment of rotation of the condylar head an axial CT scan or axial cone beam CT (or radiographic axial skull base view) were man-

datory. As conventional X-rays are progressively less available in case of modern CT diagnostics as an emergency room standard, especially panorex was often missing. Alternative up to date 3D reconstructions, however, were not suited for exact metric measurements, for example, assessing the loss of vertical ramus height. Alternatively, in CT sagittal scans, for example, measurement of vertical loss to some degree depends on the selected slices and thus, such as in 3D CT due to lack of measurement instruments of the Digital Imaging and Communications in Medicine (DICOM)-viewer, makes it difficult to define the Loukota line, which however is crucial for defining base and neck fractures and is unfortunately more or less basically panorex based. As panorex will be even less available in the future as a standard in trauma cases in favor of CT imaging, the Loukota line urgently needs a CT-based equivalent in the near future. A similar problem was also evident in an initial attempt to distinguish between high (viz. upper) versus low condylar neck fractures. However, due to high diagnosis inconsistency, the group participants agreed to remove this differentiation from the classification system. The differentiation of condylar neck fractures against condylar head fractures required clear definitions. It was generally agreed that panorex X-rays and 3D CT are required, and must be done on the AP view.

As soon as the fracture line involves the area above the condylar head reference, the fracture was defined as a head fracture, which was basically differentiated as within the pole zone or medial to the pole zone. Consensus was achieved that in case of fragmentation the clinically most relevant location (i.e., the lateral pole zone in head fractures) should be considered. This process was accompanied by more precise definitions of minor and major fragmentation (the latter one being synonymous with the classical meaning of the term "comminution").

Some atypical fractures were responsible for disagreement among the group members, such as fractures with a vertical fracture pattern involving several levels of the condylar process (see borderline cases in the appendix case collection<sup>7</sup>). Such fractures involving the condylar head and extending vertically to the condylar neck (potentially even involving the base) can be found in about 5 to 7% of all condylar head and neck fractures.<sup>27</sup> The proposed coding system allows for unambiguous identification of these single fractures instead of a double fracture pattern of both head and neck. This is consistent with the rest of the mandibular system when fractures extend over several regions.<sup>2</sup>

A displacement of the condylar head vis-à-vis the fossa has to be coded only once for each side. As far as alterations of the condyle to fossa relation are concerned, the group introduced an additional assessment of dystopic head to fossa relations, to allow an evaluation of late sequelae affecting the discological function, for example, as a consequence of deviations even in undisplaced fractures or angulations of the head following fractures with displacement. Another much discussed problem was the precise definition of dislocation fractures. According to Wassmund<sup>28</sup> and Gilhuus-Moe<sup>29</sup> a dislocation fracture can be presumed, if the degree of angulation or fragment malposition is over 60 degrees, which

nevertheless is not satisfyingly precise. During the working process we therefore defined anatomical landmarks based on axial, coronal, and sagittal CT views to give a more concise definition regarding complete or partial dislocation. One problem the group was not able to solve satisfyingly, yet, was the correct assessment of loss of vertical height in case of bilateral fractures. So far, there will remain a discrepancy between the assessments by for instance use of lateral overrides (i.e., performed according to the measurement procedure described in the brochure) and the overall loss of vertical height of the ramus due to rotational movements of the fragments, which cannot be calculated (►Fig. 13). There remain major challenges for further classification of base versus neck fractures, which so far has been defined according to the panorex-based Loukota line (►Fig. 1),<sup>4</sup> with the location of the majority of the fracture line driving the diagnosis. According to this definition, however, there was a low rate of condylar neck fractures, with 55% of the assessed fractures of the condylar process having to be defined as base fractures against 12% in the neck subregion, that is, an odd of around 4:1 base to neck fractures. In addition, many fractures were considered as borderline cases as far as the differentiation between base and neck was concerned, resulting in cases being classified as base fractures, although participants would diagnose them as neck fractures from a clinical view point (see borderline cases in the appendix case collection<sup>7</sup>). An alternative definition was thus proposed by giving more weight on the fracture lines located within the neck subregion, such as applying a one-third versus two-thirds rule (i.e., the fracture is defined as a neck fracture as soon as the fracture line runs more than one-third above the Loukota line) instead of the conventional 50 versus 50% rule. This proposal however remained to be fully evaluated.

In case of a new definition of the landmarks base versus neck (which should run more caudally according to the surgeons involved in the classification group) there might also be a better agreement in differentiating between the lower and upper neck region, which would also be of high clinical importance for the decision-making regarding the selection of approaches.

## Conclusion

At present, condylar fractures are a topic of continuous controversial discussion regarding diagnosis and management. To a large extent this debate is due to the fact that condylar fractures do not represent a homogenous entity and even more so have been subdivided by numerous and partly contradictory classifications. Thus, so far, it is very difficult to perform reliable comparisons between studies, including meta-analyses.<sup>30</sup> During the development process of this classification system it became clear, that some of the initially conceived and first of all surgery-related aspects could not be mirrored in the classification due to interobserver disparity. Nevertheless, the most relevant clinical features for establishing a diagnosis and thus supporting a treatment decision were unanimously agreed upon and implemented in the classification as described above. As in the future the CMF

classification system will be based more on advanced imaging, which will be progressively available, or even further technological advances resulting in improved (computer-assisted) diagnosis processes, a thorough and more accurate evaluation process of condylar process fractures will be facilitated. On the other hand, as a challenge for further development of the classification, the use of so far traditional, for example, panorex X-ray-based landmarks (e.g., the Loukota line) will have to be reconsidered for future classifications and adapted to CT or cone beam-based imaging modalities.

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